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NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND



TECHNICAL REPORT

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REVISED ANTHROPOMETRIC RESTRICTIONS FOR U.S. NAVY AND MARINE CORPS TRAINER AND FIXED WING NONEJECTION AIRCRAFT AND U.S. COAST GUARD HU-25

by

**Heather Tucker
Lori Brattin
William Reason**

27 June 2002

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DEPARTMENT OF THE NAVY
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND

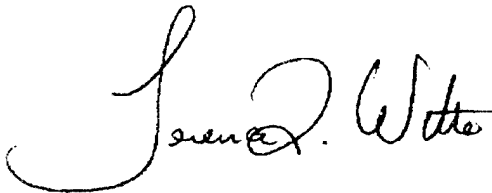
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Heather Tucker
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William Reason

RELEASED BY:

A handwritten signature in black ink, appearing to read "Terry Witte", is written over a horizontal line.

27 June 2002

TERRY WITTE / CODE 4.6.4 / DATE
Head, Cockpit/Crew Station Division
Naval Air Warfare Center Aircraft Division

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14. ABSTRACT NAVAIRSYSCOM (PMA-202) tasked NAWCAD Patuxent River, Maryland, (AIR-4.6) to perform a baseline accommodation assessment of existing U.S. Navy (USN) and U.S. Marine Corps (USMC) fixed wing nonejection aircraft and their respective trainer aircraft and establish anthropometric restriction codes (ARC's) as appropriate. The assessment also determined the estimated percentage of future candidate aviators suitable for flight duty in a particular aircraft with respect to their measured anthropometric characteristics. The percents reported were based on the population data set used to provide seven test cases cited in the Joint Services Specification Guidance 2010-3. The methods used in the assessment were different than procedures historically used to determine USN/USMC aviator suitability and to verify cockpit design with regard to aircrew accommodation. A multivariate statistical approach was employed and served as the basis for determining the safe accommodation envelopes for each platform/crew station. Revised ARC's are presented and the respective percents accommodated are summarized.									
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SUMMARY

NAVAIRSYSCOM (PMA-202) tasked NAWCAD Patuxent River, Maryland, (AIR-4.6) to perform a baseline accommodation assessment of existing U.S. Navy (USN) and U.S. Marine Corps (USMC) fixed wing nonejection aircraft and their respective trainer aircraft and establish anthropometric restriction codes (ARC's) as appropriate. The assessment also determined the estimated percentage of future candidate aviators suitable for flight duty in a particular aircraft with respect to their measured anthropometric characteristics. The percents reported were based on the population data set used to provide seven test cases cited in the Joint Services Specification Guidance 2010-3. The methods used in the assessment were different than procedures historically used to determine USN/USMC aviator suitability and to verify cockpit design with regard to aircrew accommodation. A multivariate statistical approach was employed and served as the basis for determining the safe accommodation envelopes for each platform/crew station. Revised ARC's are presented and the respective percents accommodated are summarized.

Limitations to accommodating an increased percentage of smaller dimension/weight personnel in USN/USMC fixed wing nonejection aircraft were noted. These limitations included achieving external field of view simultaneously while maintaining a capability to reach and operate primary flight controls or other immediate-action emergency controls with a locked harness. Additionally, limitations to accommodating an increased percentage of larger dimension personnel in USN/USMC fixed wing nonejection aircraft were noted. These limitations included ensuring sufficient clearances within the crew station. The ARC's and resultant percents accommodated presented within this report do not address additional accommodation limitations due to the effects of aggressive flight profiles or individual aircrew strength.

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INTRODUCTION

BACKGROUND

1. Recent reassignments of aviators within the U.S. Navy (USN)/U.S. Marine Corps (USMC) have highlighted an area where small improvements to a simple nonclinical test could save a significant amount of operational funding, and potentially reduce aviation mishaps where ill-suited anthropometrics have been cited as causal or contributory factors. These issues were revealed during the course of the NAVAIRSYSCOM (PMA-202) Aircrew Accommodation Expansion Program where NAWCAD Patuxent River, Maryland, (AIR-4.6) was tasked to perform a baseline accommodation assessment of in-service USN/USMC aircraft (reference 1). The methods used in the program approach were different than procedures historically used to determine USN/USMC aviator suitability and to verify cockpit design with regard to aircrew accommodation. A multivariate statistical approach was employed and served as the basis for determining the safe accommodation envelopes for each platform/crew station. The revised anthropometric restriction codes (ARC's) and resultant percents accommodated within this report account for the following:

- a. Estimated next generation of aviators (reference 2) and aircraft design specifications (reference 3).
- b. Location of the seat with respect to the interacting variables that affect the appropriate seat location.
- c. Statistical precision of the predicted accommodation envelope.
- d. Operational use of the codes and pipeline relational charting.
- e. Potential cost avoidance associated with assigning aviators to their suitable aircraft up front and early via the proposed ARC system presented.

These revised ARC's and percents accommodated are established from the aircrew accommodation analyses conducted under reference 1. The ARC's define the acceptable range of aircrew anthropometric dimensions that must be satisfied to achieve safety of flight and mission effectiveness, and have recently been documented in reference 4. Legacy ARC's contained in reference 5 are outdated, undocumented, and require the use of a fit check process that is subjective and, at times, cost prohibitive to send candidates to an airfield possessing the necessary aircraft to perform a fit check.

PURPOSE

2. The purpose of this report is to provide revised ARC's for USN/USMC fixed wing nonejection and trainer aircraft, and the U.S. Coast Guard HU-25, and to provide an estimated percentage of a given population that is accommodated in each aircraft.

SCOPE OF TESTS

3. Evaluations of aircrew anthropometric accommodation in the T-34C, T-2C, C-130T, C-130J, and C-40A aircraft were conducted at NAS Patuxent River, Maryland. The T-44A and TC-12B evaluations were conducted at NAS Corpus Christi, Texas. The E-2C, C-2A, and C-9B evaluations were conducted at NAS Norfolk, Virginia. The P-3C evaluation was conducted at NAS Whidbey Island, Washington. The E-6A/B evaluation was conducted at Tinker Air Force Base (AFB), Oklahoma. The C-20D/G evaluation was conducted at Andrews AFB, Maryland. The HU-25 evaluation was conducted at Elizabeth City, North Carolina. The T-6A aircraft was assessed based on available data and dialogue with the U.S. Air Force (USAF). Each of the evaluations typically required 30 hr of ground tests conducted over a 3-day period. Aircrew accommodation data were collected in both crew stations for each aircraft. In all measured test trials, subjects were attired in the full complement of summer flight gear as specified for each aircraft in reference 6. Evaluation of aircrew anthropometric accommodation included the following six functional parameters:

- a. External field of view (FOV) (ability to obtain design eye point (DEP)).
 - b. Reach to controls (ability to operate critical flight and emergency controls with a locked harness).
 - c. Reach to pedals (ability to gain adequate rudder pedal authority).
 - d. Leg clearance (ability to have lower leg clearance to the main instrument panel).
 - e. Overhead clearance (ability to have head clearance to any overhead obstructions).
 - f. Ejection clearance, when applicable (ability to safely clear cockpit structures in the event of an in-flight emergency escape via ejection).
4. The ARC's presented within this report do not address these additional accommodation issues: the effects of aggressive flight profiles, individual aircrew strength, or nonflight/enlisted crew stations.
5. Although the methods employed in this accommodation study differ from those used during aircraft design and development, the results herein reported do not necessarily imply any deficiency with respect to specification compliance by the airframe manufacturer, seat contractors, or the procuring agency.

METHOD

GENERAL

6. A pool of 10 to 12 test subjects, representing the range of candidate aviator anthropometric characteristics, as seen in figure 1 and reference 2, were measured in accordance with the methods established by reference 7. Crew station geometry and subject accommodation data were collected using the procedures outlined in reference 8.

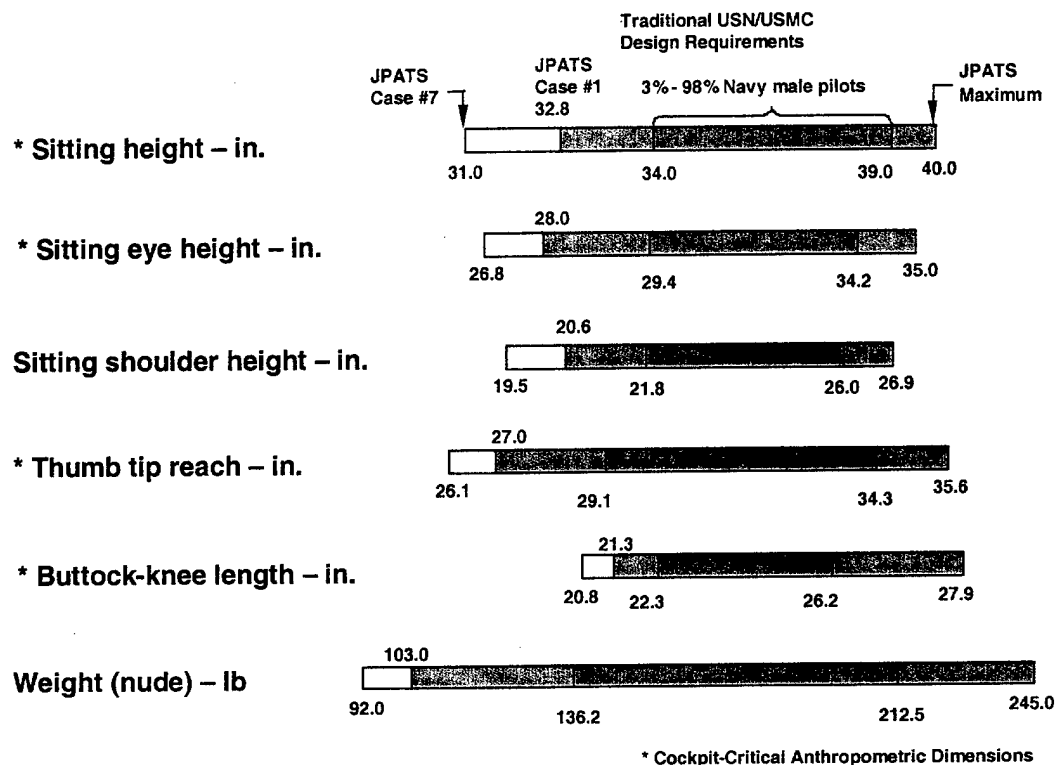


Figure 1: Past and Present USN Aircraft Accommodation Specification Criteria

DATA COLLECTION

7. The initial crew station geometry measurements were collected using the FaroArm™, an 8-ft long, 6 degree of freedom, articulating arm with an accuracy of 0.004 in. The FaroArm™ is a portable coordinate measurement machine that takes data such as points, lines, and planes in a three-dimensional coordinate system, and places these features in an AutoCAD® drawing via AnthroCAM™ software. The crew station geometry measurements were made to align the FaroArm™ with the aircraft coordinate reference system, when available, and to record the locations of flight control and cockpit control test points, clearance obstructions, and the adjustment ranges of the seat and rudder pedals.

8. After crew station geometry collection, a subject accommodation evaluation was then performed, placing each subject at four to five locations along the full range of available seat positions. Specific measurement criteria in this evaluation were as follows:

- a. Clearance measurements were taken between the top of the helmet (while the subject's head was stationary and upright) and the closest overhead surface.
- b. Lower leg clearance distances were measured between the lowest edge of the main instrument panel and the subject's shin while the feet were resting on the pedals in a normal flight position.
- c. Reach distances to pedals were measured between the full aft position of the pedals and the furthest forward pedal location where the subject achieved full rudder pedal authority.
- d. The ability of each subject to reach and operate the control stick and other essential or emergency controls in each crew station was evaluated. Reach was evaluated in the zone 2 condition (shoulder harness locked with maximal stretching of arm and shoulder).
- e. External FOV was evaluated by determining whether each subject could establish a horizontal vision line through the DEP.
- f. Ejection clearance distances were measured (when applicable) between the subject's knee and any obstruction within the ejection envelope.

DATA ANALYSIS

9. Data generated by the FaroArmTM evaluation were organized into a Microsoft Excel[®] worksheet. Data were reduced into accommodation prediction equations through multiple regression analyses. The independent variables were the subjects' anthropometric measurements and the seat adjustment heights. The dependent variables were miss/over reach or clearance distances.

10. These prediction equations were then employed to determine the accommodation envelope for each anthropometric dimension in each aircraft. The equations exhibited coefficients of determination (R^2) of 0.8 or greater. The standard error associated with each regression equation was generally less than 0.5 in. except for those involving the prediction of arm reach capability where the goal was generally to achieve 1.0 in. or less standard error.

11. Each aircraft and crew station had its own unique set of univariate thresholds established from the regression analyses.

12. The analysis was based on an expanded range of anthropometric measurements reflecting an anticipated DoD population defined in references 2 and 3. The critical cockpit anthropometric characteristics of this anticipated DoD population are covered in table 1, which defines USN/USMC fixed wing nonejection aircraft ARC's in terms of 13 proposed intervals around 4 significant cockpit-critical anthropometric dimensions, as noted by the "*" in figure 1. AIR-4.6

recommends expanding the overall anthropometric restriction coding system to match the other guidance available to airframe vendors as design criteria. AIR-4.6 also recommends the critical minimums and maximums (codes 0 and 12) be restricted as presented in table 1.

Table 1: Proposed USN/USMC Personal Anthropometric Codes

Code	Nude Body Weight (lb)	Sitting Eye Height (in.)	Thumb Tip Reach (in.)	Buttock-Knee Length (in.)	Sitting Height (in.)
0	<100 ¹	<26	<26	<20.4	<31
1	100 ² -116.5	26-26.4	26-26.4	20.5-20.9	31-31.9
2	116.6-136 ³	26.5-26.9	26.5-26.9	21-21.9	32-32.9
3	136.1-140 ⁴	27-27.4	27-27.4	22-22.4 ¹⁵	33-33.9
4	140.1-155	27.5-27.9	27.5-27.9	22.5-25.4 ^{16, 17}	34-34.4 ^{20, 21}
5	155.1-170	28-28.4	28-28.4	25.5-25.9 ¹⁸	34.5-37.4 ²²
6	170.1-185	28.5-28.9	28.5-28.9	26-26.4 ¹⁹	37.5-38.4 ²³
7	185.1-195	29-29.4 ⁹	29-29.4 ^{12, 13}	26.5-26.9	38.5-38.9
8	195.1-204 ⁵	29.5-29.9 ¹⁰	29.5-29.9	27-27.4	39-39.4 ²⁴
9	204.1-213 ⁶	30-30.4	30-30.4	27.5-27.9	39.5-39.9
10	213.1-235 ⁷	30.5-30.9	30.5-30.9	28-28.4	40-40.4
11	235.1-245 ⁸	31-31.4	31-31.4 ¹⁴	28.5-28.9	40.5-40.9
12	>245	>31.5 ¹¹	>31.5	>29	>41

Nude Body Weight

1. Below MANMED lower limit (reference 9)
2. Joint Primary Aircraft Trainer System (JPATS) seat lower limit (reference 3)
3. 3rd percentile = 136 (reference 10)
4. 5th percentile = 140 (reference 10)
5. 95th percentile = 204 (reference 10)
6. 98th percentile = 213 (reference 10)
7. MANMED upper limit (reference 9)
8. JPATS seat upper limit (reference 3)

Sitting Eye Height

9. 3rd percentile = 29.41 (reference 10)
10. 5th percentile = 29.70 (reference 10)
11. 50th percentile = 31.52 (reference 10)

Thumb Tip Reach

12. 3rd percentile = 29.07 (reference 10)
13. 5th percentile = 29.33 (reference 10)
14. 50th percentile = 31.40 (reference 10)

Buttock-Knee Length

15. 3rd percentile = 22.28 (reference 10)
16. 5th percentile = 22.50 (reference 10)
17. 50th percentile = 24.06 (reference 10)
18. 95th percentile = 25.80 (reference 10)
19. 98th percentile = 26.24 (reference 10)

Sitting Height

20. 3rd percentile = 33.96 (reference 10)
21. 5th percentile = 34.24 (reference 10)
22. 50th percentile = 36.27 (reference 10)
23. 95th percentile = 38.36 (reference 10)
24. 98th percentile = 38.95 (reference 10)

13. The proposed revised coding interval system, table 1, was used in conjunction with the resultant univariate analyses to generate the updated and revised anthropometric restriction coding for USN/USMC fixed wing nonejection aircraft. The ARC's are presented in the appendix.

14. The final ARC's were entered into a software package, Automated Anthropometric Evaluation Program, which delivers the compatibility between aircrew and aircraft.

15. A percentage of a given population was determined by dividing the number of successful accommodation values by the total number of individuals in the population data set (reference 2).

RESULTS

GENERAL

16. The results of these tests indicate recommended minimum pilot sitting eye height in USN/USMC fixed wing nonejection aircraft generally ranges from 27.5 to 28.5 in. These minimum sitting eye heights are based on external visibility requirements listed in reference 11. Individuals at or near the minimum sitting eye height will require a seat location near full up, or approximately 2 in. higher than the neutral seat reference position, to obtain a horizontal line of vision through the DEP. AIR-4.6 recommends use of the sitting eye height measurement as an anthropometric screening criterion for candidate aviators.

17. The results of these tests indicate a recommended minimum pilot thumb tip reach of 26.5 to 28.5 in. for the operation of primary flight controls and immediate action emergency controls. As a two-axis seat moves upward and aft, the occupant is pulled away from the primary flight controls, instrument panel controls, and center console controls, but is placed closer to the DEP and overhead controls. Therefore, there is a strong relationship between obtaining the requisite downward, over the nose, FOV capability and maintaining full reach capability to all controls.

18. The results of these tests indicate that a buttock-knee length of greater than 21.0 in. is recommended to gain adequate rudder pedal authority. In general, these measurements indicate that a buttock-knee length of less than 28.5 in. will safely clear the main instrument panel.

19. The results of these tests indicate a recommended sitting height of less than 41.0 in. to ensure clearance to any overhead obstructions.

AIRCRAFT SPECIFIC

T-6A

20. The results of these analyses indicate that 96.2% of the population contained in the reference 2 population data base were accommodated in both crew stations of the T-6A trainer aircraft.

T-34C

21. The results of these analyses indicate that 84.5% of the population contained in the reference 2 population data base were accommodated in the T-34C trainer aircraft forward crew station.

22. The results of these analyses indicate that 91.0% of the population contained in the reference 2 population data base were accommodated in the T-34C trainer aircraft aft crew station.

T-44A

23. The results of these analyses indicate that 77.9% of the population contained in the reference 2 population data base were accommodated in both crew stations of the T-44A trainer aircraft.

TC-12B

24. The results of these analyses indicate that 95.5% of the population contained in the reference 2 population data base were accommodated in both crew stations of the TC-12B trainer aircraft.

T-2C

25. The results of these analyses indicate that 53.6% of the population contained in the reference 2 population data base were accommodated in the T-2C trainer aircraft forward crew station.

26. The results of these analyses indicate that 63.1% of the population contained in the reference 2 population data base were accommodated in the T-2C trainer aircraft aft crew station.

C-130T

27. The results of these analyses indicate that 88.7% of the population contained in the reference 2 population data base were accommodated in both crew stations of the C-130T aircraft.

C-130J

28. The results of these analyses indicate that 88.7% of the population contained in the reference 2 population data base were accommodated in both crew stations of the C-130J aircraft.

P-3C

29. The results of these analyses indicate that 86.3% of the population contained in the reference 2 population data base were accommodated in both crew stations of the P-3C aircraft.

E-2C

30. The results of these analyses indicate that 77.9% of the population contained in the reference 2 population data base were accommodated in both crew stations of the E-2C aircraft.

C-2A

31. The results of these analyses indicate that 83.0% of the population contained in the reference 2 population data base were accommodated in both crew stations of the C-2A aircraft.

E-6A/B

32. The results of these analyses indicate that 88.8% of the population contained in the reference 2 population data base were accommodated in both crew stations of the E-6A/B aircraft.

C-40A

33. The results of these analyses indicate that 96.0% of the population contained in the reference 2 population data base were accommodated in both crew stations of the C-40A aircraft.

C-20D/G

34. The results of these analyses indicate that 88.9% of the population contained in the reference 2 population data base were accommodated in both crew stations of the C-20D/G aircraft.

C-9B

35. The results of these analyses indicate that 90.4% of the population contained in the reference 2 population data base were accommodated in both crew stations of the C-9B aircraft.

HU-25

36. The results of these analyses indicate that 89.7% of the population contained in the reference 2 population data base were accommodated in the HU-25 aircraft right crew station.

37. The results of these analyses indicate that 86.3% of the population contained in the reference 2 population data base were accommodated in the HU-25 aircraft left crew station.

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DISCUSSION

GENERAL

38. Aviator anthropometric compatibility with cockpit geometry is a safety of flight issue. OPNAV policy guidance (reference 12), direction, and tasking to lower echelon commands is essential to ensure that aviation flight duty requirements for safety of flight are assured and maintained. Incorporation of the revised ARC's presented in the appendix in future updates to references 4 and 5 will enhance the ability to safely assign aviators to fixed wing nonejection aircraft pipelines, preserve flight safety, maintain mission effectiveness, and avoid downstream costs associated with reassignment processing due to cockpit incompatibility. AIR-4.6 recommends that references 4 and 5 be updated to display anthropometric thresholds as presented in table 1. AIR-4.6 also recommends that references 4 and 5 be updated to display the ARC's as presented in the appendix.

39. Some of these aircraft land aboard aircraft carriers. Therefore, the guidance contained in reference 11 served as an operational/specification requirement. Locked harness reach tasks are not well defined by a requisite and recurring operational task. AIR-4.6 evaluates cockpit accommodation with a locked harness (reference 8) to represent the worst case scenario because of the repeatability and consistency of measurement. The NATOPS is not clear with respect to harness locking conditions throughout all phases of flight.

BUTTOCK-KNEE LENGTH VERSUS BUTTOCK-LEG LENGTH

40. The buttock-knee length measurement is used to predict leg clearance and can reasonably be used to establish adequate rudder pedal authority. In a test performed at the Naval Operational Medicine Institute in June 1999, it was determined that the buttock-knee length measurement comprised 57% of the overall leg length. This percentage was also compared to the reference 2 data set where the actual measurement process of buttock-leg length was slightly different. Nonetheless, it was consistent for the vast majority of cases examined. AIR-4.6 recommends elimination of the buttock-leg length measurement of candidate aviators as an anthropometric screening criterion as the buttock-knee length measurement is a very strong predictor of overall leg length.

CURRENT U.S. NAVY/U.S. MARINE CORPS POPULATION

41. The reference population does not correspond with current operational USN/USMC realities. According to reference 13, the projected population was designed to match the racial mix of the 1992 Department of Education college graduates who were 22 years of age or older and within the USN/USAF height and weight standards. The current proportion of females in USN/USMC aviation billets is 4.7% of the USN/USMC flying population (reference 14). The reference 2 population data base proportion is at 40% (848 females to 1,294 males). Additionally, the reference 2 population data base exhibits no personnel possessing body weights greater than 235 lb. During an AIR-4.6 evaluation in March 1998, several student naval aviators and instructors were weighed. Of the 33 aviators weighed, 8 (24%) were in excess of 213 lb and 3 (9%) were above 235 lb. AIR-4.6 recommends the reference population be adjusted on a

sliding scale to represent current and projected operational populations and validated in terms of future operational projections as soon as practicable.

AIRCRAFT SPECIFIC

T-6A

42. Both crew stations of the T-6A trainer aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the maximum buttock-knee length allowable for leg clearance to the main instrument panel.

T-34C

43. Both crew stations of the T-34C trainer aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

T-44A

44. Both crew stations of the T-44A trainer aircraft were fairly accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

TC-12B

45. Both crew stations of the TC-12B trainer aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

T-2C

46. The forward crew station in the T-2C trainer aircraft was marginally accommodating, while the aft crew station was fairly accommodating, based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in the forward crew station were noted in terms of the limited nude body weight certified for safe escape and the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness. Limitations to achieving a larger percent accommodated in the aft crew station were noted in terms of the limited nude body weight certified for safe escape.

C-130T

47. Both crew stations of the C-130T aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

C-130J

48. Both crew stations of the C-130J aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

P-3C

49. Both crew stations of the P-3C aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

E-2C

50. Both crew stations of the E-2C aircraft were fairly accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

C-2A

51. Both crew stations of the C-2A aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness and the ability to gain adequate rudder pedal authority.

E-6A/B

52. Both crew stations of the E-6A/B aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

C-40A

53. Both crew stations of the C-40A aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

C-20D/G

54. Both crew stations of the C-20D/G aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

C-9B

55. Both crew stations of the C-9B aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

HU-25

56. Both crew stations of the HU-25 aircraft were quite accommodating based on the reference 2 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

CONCLUSIONS

GENERAL

57. Minimum pilot sitting eye height in USN/USMC fixed wing nonejection aircraft generally ranges from 27.5 to 28.5 in. (paragraph 16).

58. Minimum pilot thumb tip reach ranges from 26.5 to 28.5 in. for the operation of primary flight controls and immediate action emergency controls (paragraph 17).

59. A buttock-knee length between 21.0 and 28.5 in. will generally ensure accommodation while allowing safe operation under normal and emergency conditions (paragraph 18).

60. A sitting height less than 41.0 in. ensures clearance to any overhead obstructions (paragraph 19).

AIRCRAFT SPECIFIC

T-6A

61. Both crew stations of the T-6A trainer aircraft accommodate 96.2% of the population in the reference 2 population data base (paragraph 20).

T-34C

62. The forward crew station of the T-34C trainer aircraft accommodates 84.5% of the population in the reference 2 population data base. The aft crew station accommodates 91.0% of the population (paragraphs 21 and 22).

T-44A

63. Both crew stations of the T-44A trainer aircraft accommodate 77.9% of the population in the reference 2 population data base (paragraph 23).

TC-12B

64. Both crew stations of the TC-12B trainer aircraft accommodate 95.5% of the population in the reference 2 population data base (paragraph 24).

T-2C

65. The forward crew station of the T-2C trainer aircraft accommodates 53.6% of the population in the reference 2 population data base. The aft crew station accommodates 63.1% of the population (paragraphs 25 and 26).

C-130T

66. Both crew stations of the C-130T aircraft accommodate 88.7% of the population in the reference 2 population data base (paragraph 27).

C-130J

67. Both crew stations of the C-130J aircraft accommodate 88.7% of the population in the reference 2 population data base (paragraph 28).

P-3C

68. Both crew stations of the P-3C aircraft accommodate 86.3% of the population in the reference 2 population data base (paragraph 29).

E-2C

69. Both crew stations of the E-2C aircraft accommodate 77.9% of the population in the reference 2 population data base (paragraph 30).

C-2A

70. Both crew stations of the C-2A aircraft accommodate 83.0% of the population in the reference 2 population data base (paragraph 31).

E-6A/B

71. Both crew stations of the E-6A/B aircraft accommodate 88.8% of the population in the reference 2 population data base (paragraph 32).

C-40A

72. Both crew stations of the C-40A aircraft accommodate 96.0% of the population in the reference 2 population data base (paragraph 33).

C-20D/G

73. Both crew stations of the C-20D/G aircraft accommodate 88.9% of the population in the reference 2 population data base (paragraph 34).

C-9B

74. Both crew stations of the C-9B aircraft accommodate 90.4% of the population in the reference 2 population data base (paragraph 35).

HU-25

75. The right crew station of the HU-25 aircraft accommodates 89.7% of the population in the reference 2 population data base. The left crew station accommodates 86.3% of the population (paragraphs 36 and 37).

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RECOMMENDATIONS

76. Expand the overall anthropometric restriction coding system to match the other guidance available to airframe vendors as design criteria (paragraph 12).
77. Restrict the critical minimums and maximums (codes 0 and 12) as presented in table 1 (paragraph 12).
78. Use the sitting eye height measurement as an anthropometric screening criterion for candidate aviators (paragraph 16).
79. Update references 4 and 5 to display anthropometric thresholds as presented in table 1 (paragraph 38).
80. Update references 4 and 5 to display the ARC's as presented in the appendix (paragraph 38).
81. Eliminate the buttock-leg length measurement of candidate aviators as an anthropometric screening criterion as the buttock-knee length measurement is a very strong predictor of overall leg length (paragraph 40).
82. Adjust the reference population on a sliding scale to represent current and projected operational populations and validate in terms of future operational projections as soon as practicable (paragraph 41).

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APPENDIX REVISED ANTHROPOMETRIC RESTRICTION CODES

This appendix was prepared for insertion to future releases of the NAVAIR 3710.9 and CNATRA 13520.1 series instructions. It is presented in chart format for ready viewing of pipeline relationships.

The appendix was designed to be used by personnel responsible for assigning candidate USN/USMC aviators to appropriate pipelines.

It uses the coding intervals as established in table 1, and indicates all the specification thresholds with respect to how these aircraft and future aircraft were designed. Values highlighted in pink, green, or blue above a particular coding column indicate the exact values of the 3rd and 5th (pink), 50th (green), and 95th and 98th (blue) percentiles from a 1964 USN aviator data population, reference 10.

The current CNATRA 13520.1 series instruction (reference 5) makes use of four codes: sitting height, thumb tip reach, buttock-knee length, and buttock-leg length. The codes are not evaluated in terms of their relationship to one another.

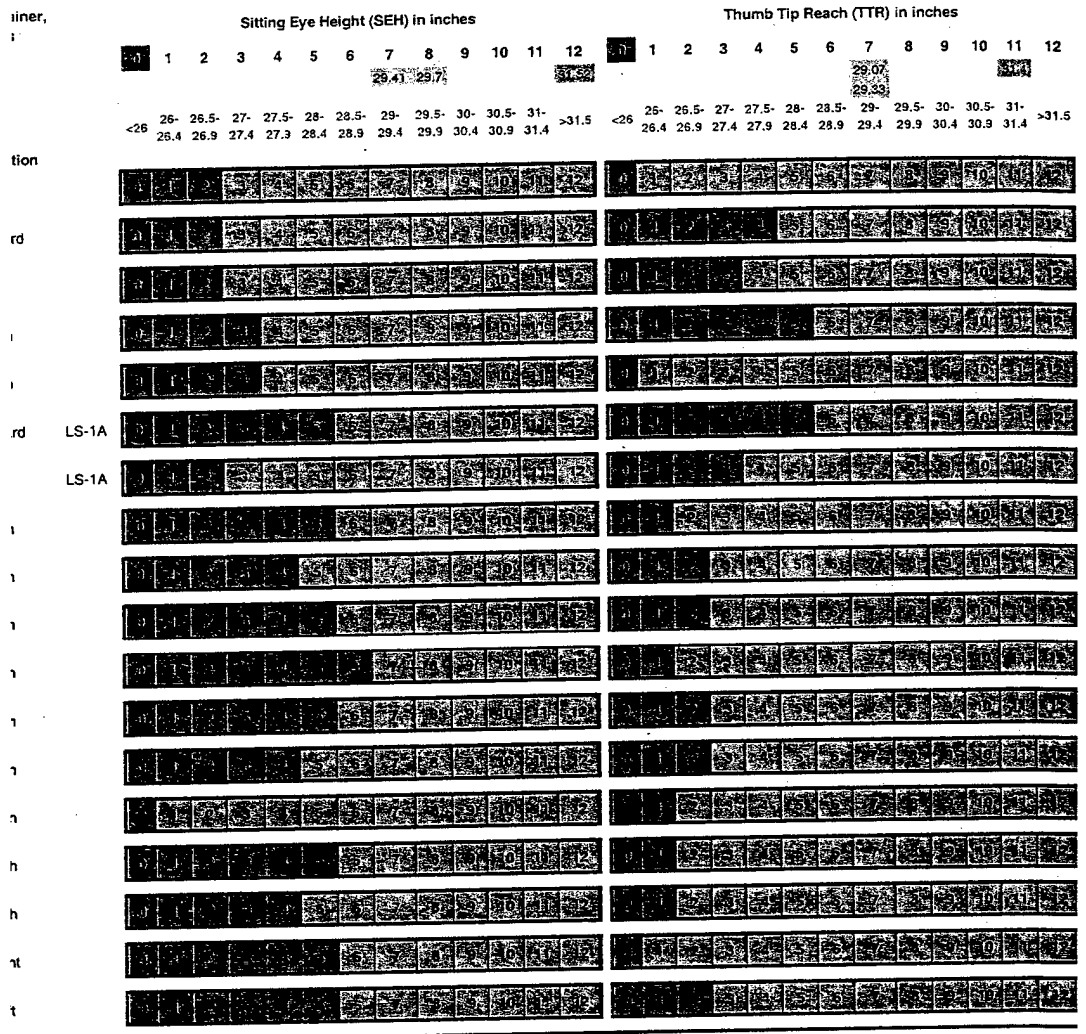
This new proposed ARC chart, documented in the latest revision of the NAVAIR 3710.9 series instruction (reference 4), accounts for eight parameters of concern. These parameters include a first pass on five criteria (sitting eye height, thumb tip reach, buttock-knee length, sitting height, and weight). To potentially be compatible with the aircraft, an individual should have each dimension within one of the green cells and meet the weight criteria listed, when applicable. Then the assessment of aviator suitability should evaluate three critical relationships:

- a. Sitting eye height and thumb tip reach (ability to attain DEP and reach to controls).
- b. Sitting eye height and buttock-knee length (ability to attain DEP and operate foot controls).
- c. Sitting height and buttock-knee length (ability to attain overhead and leg clearances).

In order to calculate the sitting eye height measurement for an individual, subtract 4.8 in. from the sitting height for males, or subtract 4.5 in. from the sitting height for females.

The ARC's were determined from AIR-4.6 univariate results that indicated thresholds required for all dimensions at various seat locations. The resultant minimums were evaluated concurrently to determine the combined scores required for the critical relationships described above.

FIXED WING NONEJECTION, TRAINER, AND U.S. COAST GUARD



ch (TTR) in inches	SEH+ TTR	Buttock Knee Length (BKL) in inches	SEH+ BKL	Sitting Height (SH) in in.	SH+ BKL	Nude Body Weight in lb
5 7 8 9 10 11 12		1 2 3 4 5 6 7 8 9 10 11 12		2 3 4 5 6 7 8 9 10 11 12		Min Max
29.07 29.53		22.26 22.5 25.8 26.24		33.58 34.24		
5- 29- 29.5- 30- 30.5- 31- 1.9 29.4 29.9 30.4 30.9 31.4	>31.5	<20.4 20.5- 21- 22- 22.5- 25.5- 26- 26.5- 27- 27.5- 28- 28.5- 20.9 21.9 22.4 25.4 25.9 26.4 26.9 27.4 27.9 28.4 28.9	>29	<31 31- 32- 33- 34- 34.5- 37.5- 38.5- 39- 39.5- 40- 40.5- 31.9 32.9 33.9 34.4 37.4 38.4 38.9 39.4 39.9 40.4 40.9	>41	
	≥6		5-21		4-20	
	≥10		5-21		4-20	
					3-20	
	≥12		6-22		4-21	
	≥7		6-23		4-22	
	≥18		8-22		4-21	140 204
					3-21	140 204
	≥10		8-23		5-22	
	≥10		7-23		5-22	
	≥11		8-23		5-22	
	≥11		9-23		6-22	
	≥11		9-23		6-22	
	≥10		6-23		4-22	
	≥5		3-23		4-22	
	≥10		7-23		4-22	
	≥9		7-23		5-22	
	≥9		8-23		5-22	
	≥11		8-23		5-22	

②

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